OUTLINE OF THE BIOSTRATIGRAPHY OF ANDAMOOKA OPALFIELD

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SUMMARY

Precious opal occurs at Andamooka in conglomerates interbedded with sandy clays carrying a rich microfauna of arenaceous foraminifera of Aptian age. A notable discovery from recent sampling is the presence of late Pleistocene or early Recent marine mollusca and foraminifera in sediments at the top of several of the shafts. This confirms the belief that late Pleistocene-early Recent high sea levels converted the area from Spencer Gulf northwards towards Lake Eyre into an extensive estuary.

INTRODUCTION

The present paper is based on micropalaeontological examination of 57 samples collected from 17 shafts over a wide area of Andamooka Opalfield by L. C. Nixon and M. B. Langsford in July and August 1958. The general geology, structure and economic geology of the field were discussed in a recent report by Nixon (1960), but biostratigraphic details were not included.

Almost without exception the Cretaceous and younger rocks are extensively kaolinized, a feature commonly produced by weathering in arid parts of South Australia and not of any particular stratigraphic significance. As a high proportion of the Lower Cretaceous foraminifera are arenaceous forms they survive the process of kaolinization but are generally preserved as distorted and deflated tests which are not always easy to identify.

STRATIGRAPHY

The sequence of lithologic units occurring on the field was tabulated by Nixon (l.c. p. 17). Disregarding the red-brown earth and red sand dune cover, three stratigraphic units are present:

1. Late Pleistocene-early Recent marine gypseous sandy clay.
2. Lower Cretaceous (Aptian) mottled red and grey clays, kaolinitic sandy shale and kaolinitic sandstone and conglomerate.
3. Upper Proterozoic (Marinoan) dolomites, quartzites, chocolate shales and brown sandstones.

UPPER PROTEROZOIC (MARINOAN)

The only pre-Cretaceous material examined was sample F 195/58 (3) from a bore near Bickford Ridge which entered chocolate shale and brown sandstone at 80 feet. These belong to the series of dolomites, slates and quartzites tentatively correlated with the Marinoan Series. They unconformably underlie the Lower Cretaceous and outcrop on the north and east of the field (Nixon l.c. p. 15 and Fig. 1).

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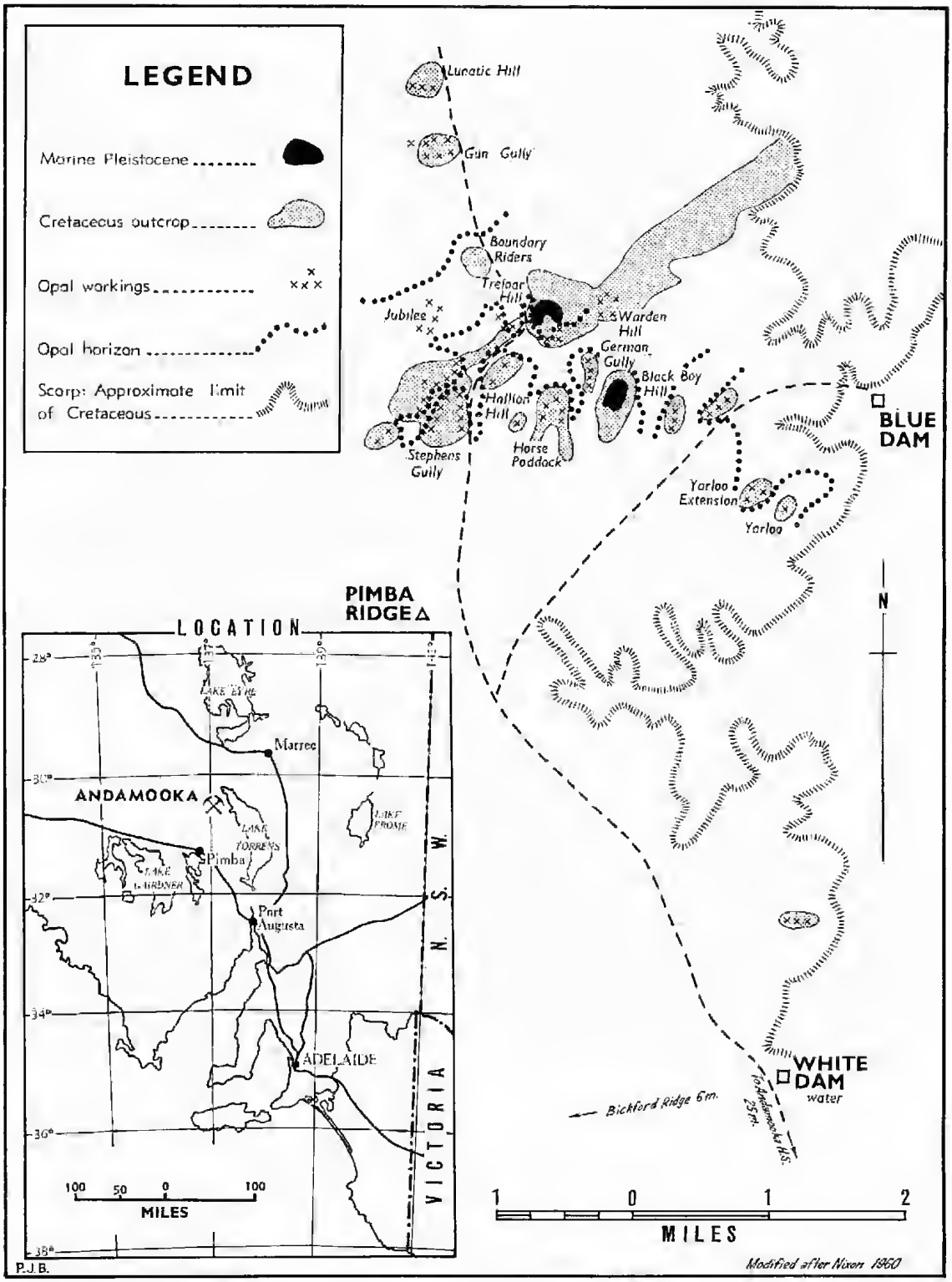

Andamooka opal field showing Cretaceous outcrops and opal workings.

LOWER CRETACEOUS (APTIAN)

The Cretaceous sediments at Andamooka consist of approximately 75 feet of interbedded clays, shales, sandstones and conglomerate. The upper half of this sequence was sampled from the "bottom gouge" or "bottom toe dirt" upwards to above the opal horizon. The accompanying Table 1 shows the distribution of foraminifera within the horizons "bottom gouge", "below the dirt", "toe dirt", "opal horizon", and "above opal horizon". Twenty-five species of arenaceous foraminifera are present, only nine of which have been described or can be identified at present with named species. They are, however, all common species occurring in the Great Artesian Basin. The assemblage is characteristic of the Aptian (Roma Formation). The "bottom gouge" and toe dirt clays are distinguished by an abundance of *Haplophragmoides chapmani* Crespin. This species has not been recognised above the Lower Albian in South Australia and occurs in varying abundance in the Aptian mainly in siltstones and mudstones. *Textularia anacooraensis* Crespin with which it is associated in most of the Andamooka samples is known to occur only in the lower part of the marine Aptian, to which *Gaudryina* sp. 3 is also limited.

"Genus A" occurs in the Aptian intersected by water bores at Marree.

Most of the associated species have less restricted ranges.

The distribution table indicates no considerable stratigraphic range and the whole of the thin Lower Cretaceous sequence probably should be placed in the lower part of the Aptian equivalent of the Roma Formation.

(1) The "bottom gouge" or lower toe dirt horizon is represented by sample F 146/58 at 29 feet depth in Terry Moore's shaft at Blackboy. The material is mostly clay, very rich in *Textularia anacooraensis* and other associated foraminifera which constitute almost the entire residue after washing.

(2) Between the "bottom gouge" and the "toe dirt" the sediments consist of fine grey-white kaolinitic and sericitic sandstone with a poor foraminiferal assemblage. Most of the samples appear to be unfossiliferous, but a few individuals of *Trochammina* sp., *Haplophragmoides chapmani*, and *Textularia anacooraensis* were recovered from samples F 159/60 and F 160/58 from the lower part of Opal No. 1, north-west of Hallion Hill. This horizon is probably represented in F 162/58 to F 166/58 from the White Dam area, F 167/58 and F 168/58 from Schulton's Shaft, Treloar Hill, and F 170/58 from Opal Creek. Sample F 167/58 carried an unusual test of *Trochammina* sp. 2 in which the agglutinated grains are of opal.

(3) "Toe dirt". Opal miners apply this name to a mottled, partially ferruginized clay or shale immediately below the opal horizon. Most of the clay disappears on washing leaving a residue rich in arenaceous foraminifera, mainly *Haplophragmoides chapmani* and *Textularia anacooraensis*. Foraminiferal tests are heavily ferruginized and brick red in colour. F 139/58, F 145/58, F 148/58, F 153/58, F 158/58, F 169/58, F 174/58, F 177/58, F 180/58, F 183/58, F 185/58, F 187/58, F 189/58, F 190/58 and F 192/58 were taken from this horizon.

(4) Opal Horizon. The conglomerate band in which the opal commonly occurs is represented by sample F 140/58 from W. Cronin's shaft at The Saddle and is distinguished by the presence of *Ammobaculites australis* (Howchin) which occurred in only one sample below this level. At German Gully the conglomerate carries fossil wood and the pelecypod *Pseudavicula australis* (Moore).

(5) Above Opal. The sediments above the opal horizon are heavily kaolinized sandstone and gypseous shale with a rather sparse microfauna in which several species of arenaceous foraminifera are generally represented in small

TABLE 1.

Distribution of Cretaceous foraminifera Andamooka opalfield.

Sample number	Bottom gouge	Below toe dirt			Toe dirt															Opal	Above opal horizon																
	F 146/58	F 159/58	F 160/58	F 167/58	F 139/58	F 145/58	F 148/58	F 153/58	F 158/58	F 169/58	F 174/58	F 177/58	F 180/58	F 183/58	F 185/58	F 187/58	F 189/58	F 190/58	F 192/58	F 140/58	F 141/58	F 144/58	F 149/58	F 152/58	F 155/58	F 156/58	F 157/58	F 161/58	F 178/58	F 182/58	F 184/58	F 188/58	F 191/58	F 193/58
Hyperammina sp. 1					v	r	—	—	c	—	c	f	—	—	—	—	—	—	r															
Pelosina lagenoides	v	—	—	—	v	—	—	—	—	—	—	—	—	—	—	—	—	—	v															
Tarotulina sp. 1																																		
Haplophragmoides chapmani	c	f	—	—	a	a	a	a	a	a	a	a	f	r	f	c	f	f	c	—	—	—	—	—	—	—	—	—	—	v	—	—	v	r
Haplophragmoides dickinsoni						r																												—
Haplophragmoides sp. 1					r																													
Haplophragmoides sp. 2												v																						
Ammobaculites australis									v	—	—	—	—	—	—	—	—	—	—	c	—	—	r	—	v	—	r	f	—	—	—	—	—	a
Ammobaculoides romarensis						v	—	—	—	—	—	—	—	—	—	—	—	—	—	v															
Textularia anacoracensis	a	r	—	r	—	c	v	—	c	c	—	v	v	—	—	—	r	v	r	r	—	—	a	—	f	f	c	—	r	—	—	—	v	c
Textularia sp. 1						f	v	—	—	r	f	—	—	—	—	—	r	—	—	—	—	—	—	—	v	—	c	r						
Textularia sp. 2						r	—	—	—	—	—	—	—	—	—	—	r	v	—	r	—	—	f	v	r	f	r	r	—	—	—	—	—	f
Textularia sp. 3											v	—	v	—	—	—	v	v	f		—	—	v	—	—	r	v	—	—	—	—	—	—	c
Textularia sp. 5	c	—	—	—	—	f	—	—	r	—	—	—	—	—	—	—	—	—	—	r	—	—	—											
Siphotextularia sp. 2						c	—	f	f	f	a	f	f	—	—	v	—	—	c				v											
Spiroplectammina cushmani											v																							
Spiroplectammina edgelli											v																							
Trochammina minuta	v	—	—	—	—	v	—	—	—	—	—	—	—	—	—	—	v	—	—	—	—	—	a	—	c	r	—	a	r					
Trochammina sp. 2	—	—	r	v	—	—	—	—	—	—	v	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r						
Gaudryina sp. 1																										v								
Gaudryina sp. 3																				f	—	—	—	—	a	—	—	f						
Gaudryinella sp. 1	f	—	v	—	—	f	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—	f										
Gaudryinella sp. 2												r	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	r	f
Genus A									v	—	—	—	—	—	—	—	—	—	—	—	—	v	—	—	—	r	—	v						

v very rare 1-2 specimens
r rare 3-5 specimens
f frequent 6-10 specimens
c common 11-25 specimens
a abundant 25 specimens.

numbers. *Textularia anacooraensis* and *Trochammina minuta* are usually present. *Haplophragmoides chapmani* was absent from all but two samples.

PLEISTOCENE-EARLY RECENT

The detection of Recent species of foraminifera and mollusca in samples taken from Kevin's shaft, German Gully, and W. Cronin's shaft, The Saddle, is quite unexpected. This discovery provides positive evidence of the existence of a late Pleistocene or early Recent estuary extending northwards from Spencer Gulf by way of Lake Torrens towards Lake Eyre where brackish water or estuarine foraminifera were recovered from clays intersected in two shallow boreholes and from a thick shell bed with *Coxiella gilesi* 36 feet above the present level of the lake (Ludbrook, 1956).

The foraminiferal assemblage in the sample from Kevin's Shaft consists of *Cribrobulimina polystoma* (Parker and Jones), *Nubeculuria lucifuga* Defrance, abundant *Peneroplis planatus* (Fichtel and Moll), *Discorbis mira* Cushman, *Elphidium cf. craticulatum* (Fichtel and Moll). Associated molluscan species are *Macoma deltoidalis* (Lamarck), *Diala lauta* (Adams), *Salinator fragilis* (Lamarck), *Batillaria* (*Zeacumantus*) *diemenensis* (Quoy and Gaimard). Both the foraminifera and mollusca are well preserved. The assemblage is typical of that living in very shallow water in warm, sheltered inlets in South Australia at the present time.

Several other samples from the Gun Gully-Lunatic Hill area contained sporadic examples of *Elphidium*, *Cibicides refulgens*, and bryozoa, but as they appeared to be fortuitous no conclusions are drawn from their occurrence.

Fresh water ostracoda and oogonia of *Chara* were present in samples F 166/58 from White Dam and F 195/58 in red clayey sand from the bore near Bickford Ridge. These are considered to have been recently deposited.

DESCRIPTION OF THE SAMPLES

(1) W. *Cronin's Shaft*, The Saddle.

F 139/58. Floor of shaft.
Iron-stained red and grey clay, washed residues consisting of ferruginized clay, fine angular quartz grains, ferruginized foraminifera.
The sample contains a mixture of Cretaceous and Recent species. The Cretaceous species are dominated by *Haplophragmoides chapmani* and *Textularia anacoorensis*. The Recent species are *Discorbis mira* Cushman, *Elphidium cf. craticulatum* (F. & M.), *Peneroplis planatus* (F. & M.) and *Marginopora vertebralis* Blainville. It would appear that Pleistocene-early Recent material assumed to occur at the top of the shaft has fallen in and contaminated the toe dirt forming the bulk of the sample.

F 140/58. Immediately above toe dirt-opal horizon.
White kaolinitic sandstone with *Ammobaculites australis*. Washings consist of medium angular quartz grains, kaolin, gypsum and some muscovite.

F 141/58. 5 feet above F 140/58. Kaolinitic sandstone with fine to medium angular to subrounded quartz grains with pitted surfaces, some hematite. No microfossils observed.

(2) *Bill's Shaft, Hard Hill*, near German Gully.

F 142/58. At 2 feet depth kaolinized clayey sandstone with medium fine subrounded quartz grains and a good deal of iron staining. No microfossils observed.

F 143/58. At 10 feet depth. Hard resilicified kaolinitic sandstone.
F 144/58. At 20 feet. White kaolinitic sandstone with a few foraminifera.
F 174/58. At 25 feet. Iron-stained mottled siltstone—toe dirt—with abundant foraminifera dominated by *Haplophragmoides chapmani* (68 examples).

(3) *Terry Moore's Shaft*, Blackboy.
F 145/58. 27-28 ft. 6 in. Mottled red and grey clay (toe dirt), washings consisting of kaolin, fine angular quartz grains, abundant partly ferruginized foraminifera dominated by *Haplophragmoides chapmani* (84 examples) and *Textularia anacooraensis*.
F 173/58. 28-29 feet. Hard kaolinitic grit with quartzite pebbles.
F 146/58. At 29 feet. Lower toe dirt horizon. Most of the sample is clay and the residue consists almost entirely of foraminifera, with *Textularia anacooraensis* in abundance (76 examples).

(4) *Yarloo Extension.*
F 147/58. White gypseous kaolinitic rock, the washings consisting mostly of kaolin and gypsum, with a fragment of precious opal. Two doubtful foraminifera only were observed.

(5) *Jubilee.*
F 148/58. No. 1. 19 ft. 6 in. Toe dirt with abundant ferruginized foraminifera, mostly *Haplophragmoides chapmani.*
F 149/58. No. 2. 15 feet. White kaolinized sandstone, with fine angular quartz grains, muscovite, very abundant *Textularia anacooraensis*, and abundant *Trochammina minuta.*

(6) *Kevin's Shaft*, German Gully.
F 150/58. Red surface sandy clay with medium subangular to subrounded quartz grains and grains of silicified sandstone. Abundant iron oxide staining.
F 151/58. At 14 feet. Mottled red and white soft gypseous sandy clay with fine quartz grains and some iron oxide. The sample contains well-preserved foraminifera and mollusca living in shallow estuaries at the present time.
Foraminifera
Cribrobulimina polystoma (Parker and Jones) (1 specimen).
Nubecularia lucifuga Defrance (1 specimen).
Peneroplis planatus (F. & M.) (23 specimens).
Discorbis mira Cushman (1 specimen).
Elphidium cf. *craticulatum* (Fichtel and Moll) (1 specimen).
Mollusca
Macoma deltoidalis (Lamarck) (1 valve).
Diala lauta (Adams) (3 specimens).
Salinator fragilis (Lamarck) (4 specimens).
Batillaria (*Zeacumantus*) *diamenensis* (Q. & G.) (1 specimen).
The material is probably of late Pleistocene or early Recent age.
There is in addition a test of *Trochammina* sp. which may be of Cretaceous age.
F 152/58. At 28 feet. Channel sample over 5 to 6 feet.
White kaolinized shale with fine angular quartz grains, sericite and one specimen each of *Textularia* sp. 2 and *Gaudryinella* sp. 1.
F 153/58. At 30 feet. Toe dirt. Mottled reddish and grey-green clay with abundant *Haplophragmoides chapmani* (58 specimens).

(7) *Garvie's Shaft*, Hallion Hill.

F 154/58. At 6 feet. Hard white kaolinized and silicified sandy shale. No foraminifera were detected.

F 155/58. At 13 feet. White kaolinized sandy shale, with fine to medium angular to subrounded quartz grains, limonite and abundant foraminifera dominated by *Gaudryina* sp. 3 (44 specimens).

F 156/58. At 17 ft. 9 in. White kaolinized sandy shale with fine to medium angular quartz grains and foraminifera dominated by *Textularia anacooracnsis* (10 specimens).

(8) *Shaft, Horse Paddock.*

F 157/58. Above opal horizon. White kaolinized sandstone with fine angular quartz grains and a foraminiferal assemblage with a few individuals of several species.

F 158/58. Toe dirt. Ferruginized clay with subrounded to angular quartz grains and abundant foraminifera dominated by *Haplophragmoides chapmani* (66 specimens).

(9) *Opal No.* 1, north-west of Hallion Hill.

F 171/58. 0-1 feet. Hard kaolinized sandy clay. No fossils observed.

F 172/58. 4 ft. 7 in.-5 ft. 6 in. Hard kaolinitic sandstone and conglomerate with occasional facetted pebbles.

F 159/58. 7 ft. 3 in.-10 ft. 2 in. White iron-stained sandy clay with *Haplophragmoides chapmani*. One fragment of precious opal noted.

F 160/58. 10 ft. 3 in.-11 ft. Mostly pinkish white kaolinized sandstone with a few impoverished foraminifera.

(10) *Stevens Gully.*

F 161/58. Adit. Grey-white kaolinitic fine sandstone with fine angular quartz grains, abundant sericite and foraminifera dominated by *Trochammina minuta* (67 specimens).

(11) *White Dam Area.*

F 162/58. East end, working 1½ miles from White Dam. 3 feet. Partly ferruginized kaolinitic sandy shale with fine angular quartz grains, hematite and limonite staining.

F 163/58. 1½ miles from White Dam; soil profile as at Andamooka. 2 feet. Iron-stained kaolinitic sandy shale with fine to medium angular iron-stained quartz grains.

F 164/58. 1½ miles north-west of White Dam. 3 feet. Kaolinized shale with some iron-staining and abundant sericite.

F 165/58. Central workings, bearing 020° from White Dam 300 yds. Iron-stained kaolinized sandy shale.

F 166/58. White Dam. Brownish-white kaolinitic sandstone. Washings consist of light brown fine to medium angular to subrounded quartz grains with much limonite staining. A shell fragment and an oogonium of *Chara* are present, but it is uncertain whether these are of Pleistocene age or of recent introduction.

(12) *Schulton's Shaft*, Treloar Hill.

F 167/58. Below toe rock. White kaolinized shale with some rounded and subangular quartz grains, sericite, a piece of precious opal and a test of *Trochammina* sp. 2 with opaline quartz grains.

F 168/58. At 40 feet. Grey kaolinitic sandstone with sericite.

F 169/58. Toe dirt. Purplish ferruginized shale with abundant ferruginized arenaceous foraminifera dominated by *Haplophragmoides chapmani* (83 specimens).

(13) *Opal Creek.*

F 170/58. Dirty white kaolinitic sandstone with fine even-grained angular quartz grains. No foraminifera were observed.

F 175/58. Hard dark ferruginized sandstone (a) R.L. 945; (b) R.L. 941.

(14) *Lunatic Hill.*

F 177/58, Locality 81 (1). Toe dirt. Mottled ferruginized shale with abundant foraminifera dominated by *Haplophragmoides chapmani* (37 specimens).

F 178/58. 81 (2). 5 ft. above 81 (1). White kaolinized sandy clay. Washings consist mainly of kaolinitic material with fine angular quartz grains and sericite. Cretaceous foraminifera are present, together with *Cibicides refulgens* and bryozoal fragments. The sample, therefore, seems to be a mixture of Cretaceous and Pleistocene material.

F 179/58. 81 (3). 5 feet above 81 (2). Powdery white kaolinitic sand, with iron-stained rounded to subrounded and polished quartz grains.

F 180/58. 82 (1). Toe dirt. Red brown ferruginous shale with *Haplophragmoides chapmani.*

F 181/58. 82 (2). 5 feet above 82 (1). White sandy kaolinized rock, with *Elphidium* cf. *macellum* (F. & M.). ?Pleistocene.

F 182/58. 82 (3). 5 feet above 82 (2). White kaolinized shale with *Haplophragmoides chapmani* and two fragments of ?Pleistocene shell.

F 183/58. 83 (1). Kaolinitic rock with fine angular quartz grains and *Haplophragmoides chapmani.*

F 184/58. 83 (2). 5 feet above 83 (1). Kaolinized shale with medium subrounded quartz and sericite.

F 185/58. 84 (1). Red and white mottled kaolinitic sandy shale with subrounded quartz grains and *Haplophragmoides chapmani.*

F 186/58. 84 (2). 5 feet above 84 (1). Hard white kaolinized sandstone.

(15) *Gun Gully.*

F 187/58. 85 (1). Toe dirt. Pink and white mottled ferruginized shale with abundant *Haplophragmoides chapmani.* There is also one specimen of *Quinqueloculina vulgaris* presumably contaminating from the overlying Pleistocene.

F 188/58. 85 (2). 5 feet above 85 (1). Somewhat ferruginized soft gypseous sandy clay with *Globigerina bulloides, Discorbis* sp. and bryozoa, indicating a Pleistocene or early Recent age.

F 189/58. 86 (1). Toe dirt. Mottled ferruginized shale with *Haplophragmoides chapmani, Textularia anacooraensis.*

F 176/58. 86 (2). 5 feet above 86 (1). Gypseous clay.

(16) *Boundary Riders Hill.*

F 190/58. 88 (1). Mottled red and grey ferruginized shale with *Haplophragmoides chapmani* and *Textularia anacooraensis.*

F 191/58. 88 (2). 5 feet above 88 (1). Kaolinized sandstone with, rarely, *Haplophragmoides chapmani* and *Textularia anacooraensis.*

F 192/58. 89 (1). Toe dirt. Pinkish sandy shale with *Haplophragmoides chapmani* and other species in relative abundance.

F 193/58. 89 (2). 5 feet above 89 (1). White kaolinitic sandstone with abundant foraminifera, including *Ammobaculites australis* and *Textularia anacooraensis.*

F 194/58. 89 (3). 5 feet above 89 (2). Soft powdery clayey sand and kunkar with mostly subrounded iron-stained quartz grains. A sponge spicule and one specimen of *Textularia* were the only organic remains recovered. The sample may be of Pleistocene age.

(17) *Near Bickford Ridge.*

F 195/58. Three samples from bore collected from spoil.

(1) Reddish and buff clayey sand with medium subangular to subrounded quartz grains with both clear and iron-stained quartz grains. Organic remains consist of ostracode fragments, *Chara* and molluscan shell fragments, the age of which is probably Recent.

(2) Sandstone and chocolate shale, containing a small *Trochammina* and two small shell fragments of diverse origin.

(3) Chocolate brown sandstone—presumably bedrock.

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